*Public Opinion Quarterly* (2023) **Vol 87 No 2,** 357–388

# Increasing the Acceptance of Smartphone-Based Data Collection

Alexander Wenz[1,*], Florian Keusch[2]

[1]Research Fellow, Mannheim Centre for European Social Research, University of Mannheim, Mannheim, Germany
[2]Professor of Social Data Science and Methodology, Department of Sociology, School of Social Sciences, University of Mannheim, Mannheim, Germany

**Abstract** To study human behavior, social scientists are increasingly collecting data from mobile apps and sensors embedded in smartphones. A major challenge of studies implemented on general population samples, however, is that participation rates are rather low. While previous research has started to investigate the factors affecting individuals' decision to participate in such studies, less is known about features of the study design which are under the researcher's control and can increase the acceptance of smartphone-based data collection methods. Guided by the Technology Acceptance Model, we varied study characteristics in a vignette experiment to examine their effect on individuals' willingness to download a research app on their smartphone. Data were collected from 1,876 members of the NORC AmeriSpeak Panel, a probability-based panel of the general population aged 18+ in the United States. Respondents were randomly assigned to eight vignettes and, after each vignette, were asked to rate their willingness to participate in the described hypothetical study. The results show that individuals are more willing to participate in smartphone-based studies where they have some control over the data collection process, by having the option either to temporarily switch off the data collection or to review the data before submission. Furthermore, they are more willing to participate in research to which they are invited via postal letter rather than receiving a postal letter plus a phone call from an interviewer who walks them through the app installation. Finally, unconditional incentives increase their willingness to engage with smartphone-based data collection over conditional incentives.

*Corresponding author: Alexander Wenz, Mannheim Centre for European Social Research, University of Mannheim, A5, 6, 68131 Mannheim, Germany; email: a.wenz@uni-mannheim.de.

Advance Access publication June 12, 2023

https://doi.org/10.1093/poq/nfad019

## Smartphone-Based Data Collection

Social scientists increasingly use smartphones for collecting data about people's attitudes and behaviors (Link et al. 2014; Harari et al. 2016; Struminskaya et al. 2020a). Smartphones allow researchers to administer survey questions to respondents and, at the same time, passively collect behavioral data from the smartphone's operating system and built-in sensors. This integration of survey- and sensor-based methods of data collection has substantial benefits for measurement (Struminskaya et al. 2020a; Keusch and Conrad 2022; Keusch and Kreuter 2022): passively collected sensor data have the potential to improve the measurement of behaviors by providing more detailed as well as more objective data that are not susceptible to recall error, social desirability bias, and other prevalent errors in self-reports. Survey data, in turn, can provide relevant contextual information about these behaviors, such as attitudes or behavioral intentions, which cannot be inferred from the sensor data.

While most previous smartphone-based studies have relied on small convenience samples that were recruited from special populations, such as college students, an increasing number of studies have started to implement mobile app and sensor data collection in larger samples of the general population (e.g., Scherpenzeel 2017; Jäckle et al. 2019; Kreuter et al. 2020; McCool et al. 2021; Struminskaya et al. 2021). A major limitation of existing studies, however, is that participation rates are rather low. The IAB-SMART study, for example, which recruited participants from a household panel survey of the residential population aged 15+ in Germany to measure the effects of long-term unemployment on social integration and social activity using a smartphone app, achieved a participation rate of only 14.5 percent (Keusch et al. 2022). Other smartphone-based studies in the general population reported participation rates in a similar range (e.g., Scherpenzeel 2017; Jäckle et al. 2019; McCool et al. 2021; Struminskaya et al. 2021). Realizing the potential of these emerging data collection methods for population inference critically depends on the ability to get larger parts of the population engaged with these forms of data collection. Nonparticipation bias is an additional concern and might arise if sample members who are willing to participate in smartphone-based data collection are different on the outcomes of interest from those not willing to participate. In this paper, we report the results from a vignette experiment conducted in a probability-based panel of the general population in the United States to examine the effect of different study characteristics that are under the researcher's control on individuals' willingness to download a research app on their smartphone.

## Barriers to Participation in Smartphone-Based Studies

Several potential barriers might prevent sample members from participating in mobile app and sensor data collection (Jäckle et al. 2019; Wenz, Jäckle, and Couper 2019). An initial barrier is access to a smartphone (Couper et al. 2018; Antoun et al. 2019; Keusch et al. 2023). Among smartphone users, a second potential barrier is their ability to use their device for the requested data collection task (Roque and Boot 2018). A final potential barrier is people's willingness to give consent for data sharing and engage in the requested data collection task (Keusch et al. 2019; Wenz et al. 2019). While previous research has started to address the first two barriers (e.g., Scherpenzeel 2017; York Cornwell and Cagney 2017; Sugie 2018), the mechanisms affecting individuals' decision to participate in mobile app and sensor data collection are not yet fully understood. Thus far, studies have shown that not only respondent characteristics but also features of the study design, such as the type of organization sponsoring the study or the duration of the data collection period, can influence people's stated willingness to engage in smartphone-based data collection (e.g., Keusch et al. 2019; Struminskaya et al. 2020b). Less is known about features of the data collection that are under the researcher's control and can be modified to increase the acceptance of smartphone-based data collection methods, such as the format of the study invitation or the types of incentives provided to participants, and how they interact with respondent characteristics.

In the next section, we review the related work on mechanisms affecting individuals' decision process for participating in smartphone-based data collection. We then present our hypotheses and the design of the vignette experiment. To test the hypotheses, we analyze the effect of five study characteristics on willingness to participate and their interaction with respondent characteristics. We conclude the paper with a discussion of our findings and the practical implications for smartphone-based research.

## Previous Research

A growing body of research has examined the factors affecting individuals' stated willingness to participate (WTP) in mobile app and sensor data collection, and has distinguished between respondent and study characteristics. Among respondent characteristics, previous research has found that privacy concerns (Keusch et al. 2019; Revilla, Couper, and Ochoa 2019; Wenz et al. 2019; Struminskaya et al. 2020b) and smartphone experience are the most predictive correlates of individuals' stated WTP (Pinter 2015; Keusch et al. 2019; Wenz et al. 2019; Struminskaya et al. 2020b) as well as actual participation in mobile app and sensor data collection (Elevelt, Lugtig, and Toepoel 2019; Struminskaya et al. 2021). The effect of several other

respondent characteristics on WTP and actual participation has been studied, such as age, gender, educational attainment, and attitudes toward surveys and research, but with nonsignificant or mixed results (Keusch et al. 2019; Revilla et al. 2019; Wenz et al. 2019; Struminskaya et al. 2020b; Struminskaya et al. 2021).

Study characteristics that have been shown to influence individuals' WTP include the type of data collection task. WTP is higher for tasks in which study participants actively complete the measurement and, thus, have more control over the data collection process, such as completing a survey on a smartphone, than for tasks where data are collected passively, such as geolocation tracking (Revilla et al. 2016; Revilla et al. 2019; Wenz et al. 2019; Struminskaya et al. 2020b). Previous research has started to examine whether giving participants more control over the data collection positively affects their WTP but has found mixed results, suggesting that the type of control might play a role. Keusch et al. (2019), for example, have shown that individuals are more willing to download a passive tracking app on their smartphone if they are offered the option to temporarily switch off the data collection. Struminskaya et al. (2020b), in turn, offered participants the option to review and edit the collected data for various data collection tasks but have found positive effects on WTP for only a subset of the tasks, with similar patterns in a study that measured actual participation (Struminskaya et al. 2021).

Additional study characteristics that have been shown to influence individuals' WTP are the duration of the data collection period, the type of organization sponsoring the study, and the format of the study invitation: individuals express higher levels of willingness to participate in smartphone-based studies that run over a shorter period of time and are sponsored by a university rather than a market research company or statistical agency (Keusch et al. 2019; Struminskaya et al. 2020b). If individuals receive multiple requests within a study to participate in data collection tasks, their WTP is higher for the first task request than for any subsequent requests (Silber et al. 2018; Keusch et al. 2019; Struminskaya et al. 2020b). Furthermore, individuals' WTP increases if they receive a study request repeatedly, such as in the context of a panel study (Struminskaya et al. 2020b). Finally, the mode of study invitation also plays a role: inviting sample members to a smartphone-based study within a face-to-face interview has been shown to increase actual participation rates compared to invitations sent via postal letter (Jäckle et al. 2022). If study invitations are sent via postal letter, however, they yield higher actual participation rates when used in combination with email invitations (Lawes et al. 2022).

A few studies have also experimented with different types of incentives to increase individuals' WTP and actual participation in smartphone-based research. Keusch et al. (2019), for example, have shown that offering monetary

incentives for both downloading an app and leaving the app installed on a smartphone until the end of the study increases individuals' WTP compared to offering just one of these incentives or no incentives. In addition, the incentive amount plays a role, with higher incentives yielding higher actual participation rates (Haas et al. 2021; McCool et al. 2021; for an exception see Jäckle et al. 2019). Beyond monetary incentives, Wenz et al. (2020) have tested the effectiveness of offering personalized feedback for increasing actual participation in smartphone-based studies, by providing a summary of the reported data, but have found no significant effects on participation rates.

This study adds to the growing body of literature on individuals' decision to participate in mobile app and sensor data collection by focusing on study characteristics that can be modified by researchers to increase individuals' acceptance of smartphone-based research. In addition to examining the main effects of the study characteristics, we investigate their interaction with respondent characteristics, which has received little attention in previous research (Wenz et al. 2019) but can provide insights about whether the study characteristics have similar effects across population subgroups. By using data from a probability sample of the general population in the United States, our study expands upon existing research that has often relied on online access panels and has mainly been conducted in Europe.

## Hypotheses

Research on consumer behavior and technology use is often informed by the Technology Acceptance Model (Davis 1986, 1989) and its extension by Gefen, Karahanna, and Straub (2003). This model postulates that technology adoption is a function of *perceived ease of use*, *perceived usefulness*, and *perceived trustworthiness of the technology*. Although we do not measure these constructs directly, our experiment varied one feature intended to increase perceived ease of use, two features intended to increase perceived usefulness, and two features intended to increase perceived trustworthiness, with the aim of increasing individuals' WTP in mobile app and sensor data collection (figure 1).

### Readability of the Data Protection and Privacy Statement

Previous research has found that privacy concerns and limited trust in the data collection organization are one of the most predictive correlates of WTP in mobile app and sensor studies (Keusch et al. 2019; Revilla et al. 2019; Wenz et al. 2019; Struminskaya et al. 2020b). Privacy policies, however, are often written in a complex fashion, and many individuals do not read them or have difficulties understanding them (Pew Research Center 2019). For researchers, it is therefore of paramount importance to communicate the

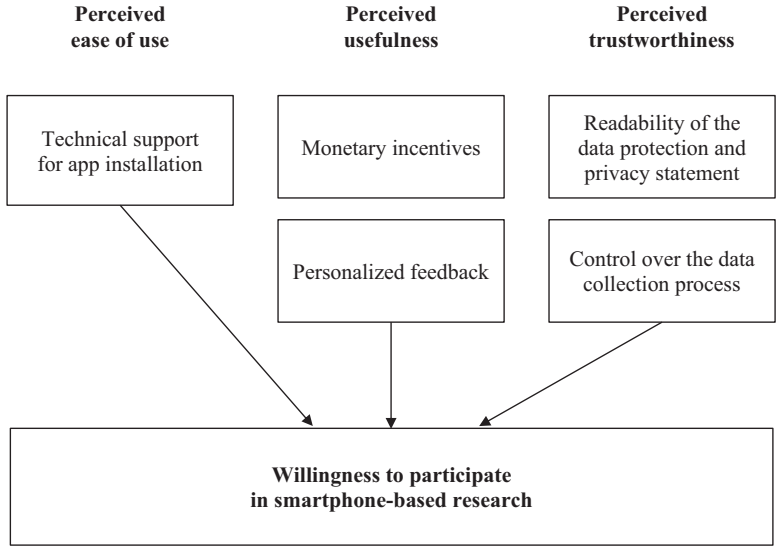


**Figure 1.** Study-level determinants of willingness to participate in smartphone-based research following components of the Technology Acceptance Model by Davis (1986, 1989) and Gefen et al. (2003).

measures which are in place to protect participant data as well as any potential risks involved with study participation in a transparent and simple manner, in line with prevailing data protection regulations. Communicating data protection and privacy statements in a simpler manner might help alleviate individuals' privacy concerns about the collection of app and sensor data and increase the *perceived trustworthiness* of the app technology. Clear communication might, thus, increase individuals' WTP in the study, in particular for those with higher levels of concerns and those with lower educational attainment who might have greater difficulties understanding the statements. Previous research on consent to data linkage has shown that the understanding of consent requests varies significantly by educational attainment (Edwards and Biddle 2021; Jäckle et al. 2021; Sakshaug et al. 2021). We therefore hypothesize:

*H1.1. Providing simpler data protection and privacy statements in the study invitation increases individuals' WTP.*

*H1.2. Providing simpler data protection and privacy statements in the study invitation has a larger positive effect on WTP for individuals with higher levels of privacy concerns compared to those with lower levels of concerns.*

*H1.3. Providing simpler data protection and privacy statements in the study invitation has a larger positive effect on WTP for individuals with*

*lower educational attainment compared to those with higher educational attainment.*

## Technical Support for App Installation

The installation process of a research app collecting sensor data requires sample members to perform multiple steps before they can take part in the study (Kreuter et al. 2020). They have to not only find and download the application in the app store, but also sign in to the app using a registration code provided by the researcher and accept the operating system's permissions to access personal information. In line with prevailing data protection regulations, they also have to provide informed consent to the individual data packages that will be collected in the study, as part of a second consent request. The multitude of steps in this installation process might deter sample members from participating in the study, especially those with limited experience downloading apps on their mobile device. Previous research confirms that technical problems during app installation or lack of confidence to download apps are among the most frequently mentioned reasons for not downloading and installing an actual research app (Jäckle et al. 2019). Providing technical support, for example by means of a telephone interviewer who walks sample members through all steps to fully set up the app and shows how to use the app, might facilitate this process, thus increasing the *perceived ease of use* of the research app technology. As a result, this measure might increase individuals' WTP in the study, in particular for those with lower levels of smartphone experience. We therefore hypothesize:

*H2.1. Providing technical support during app installation increases individuals' WTP.*

*H2.2. Providing technical support during app installation has a larger positive effect on WTP for individuals with lower levels of smartphone proficiency compared to those with higher levels of proficiency.*

## Control over the Data Collection Process

Previous research has shown that individuals state that they are more willing to participate in data collection tasks in which they actively complete the measurement, such as completing a survey on their smartphone, than in tasks where data are passively collected and transmitted to the researcher, such as tracking geolocations or online behavior (Revilla et al. 2016; Revilla et al. 2019; Wenz et al. 2019; Struminskaya et al. 2020b; Struminskaya et al. 2021). Having more control over the data is likely to make the data collection process more transparent and alleviate privacy concerns that participants might have, increasing the *perceived trustworthiness*

of the data collection technology. Although the type of sensor data being collected (i.e., active measurement vs. passive tracking) depends on the study objective, participants might also be given more control in tasks with passive data collection, for example by offering the option to turn off the data collection for some time or to review the collected data before submission. We therefore hypothesize:

*H3.1. Giving study participants more control over their data during data collection increases individuals' WTP.*

*H3.2. Giving study participants more control over their data during data collection has a larger positive effect on WTP for individuals with higher levels of privacy concerns compared to those with lower levels of concerns.*

## Monetary Incentives

Monetary incentives have consistently been shown to increase response rates in surveys, with prepaid (unconditional) incentives yielding higher response rates than promised (conditional) incentives (Church 1993; Singer and Ye 2013). However, it is still unclear whether these mechanisms also carry over to mobile app and sensor data collection. Similar to the survey context, prepaid incentives provided to all sample members during the app study invitation might be more salient and, thus, more effective in influencing participation decisions than promising incentives at the end of the study to participants. Studies involving app and sensor data collection often run over multiple days, weeks, or even months, and researchers might consider incentivizing participants to stay engaged with the study and increase the *perceived usefulness* of the research app technology. Conditional incentives might, for example, be provided to participants if they left the app installed for the entire study period (paid as a fixed amount) or for each day that participants leave the app installed on their device (paid as incremental amounts). Conditional incentives paid as incremental amounts might be more attractive to participants, and, thus, more effective in increasing their willingness to participate in the study than those paid as fixed amounts since participants would receive an incentive even if they did not fully adhere to the study protocol. We therefore hypothesize:

*H4.1. Providing unconditional monetary incentives increases individuals' WTP over conditional monetary incentives.*

*H4.2. Providing conditional monetary incentives paid as incremental amounts increases individuals' WTP over those paid as fixed amounts.*

## Personalized Feedback

Providing personalized feedback to participants at the end of the study, such as about how their individual study results compare to average results from

the general population, might serve as an additional incentive to engage with mobile app and sensor data collection. The feedback might raise participants' interest in the study since they receive a tangible benefit in exchange for their participation and might, thus, increase the *perceived usefulness* of the research app technology. We therefore hypothesize:

*H4.3. Providing personalized feedback as a nonmonetary incentive increases individuals' WTP over no feedback.*

## Methods

The data were collected in the NORC AmeriSpeak Panel, a probability-based panel of the general population aged 18+ in the United States,[1] between July 26 and August 9, 2021. The study was conducted as part of Time-sharing Experiments for the Social Sciences (TESS).[2] Panel members received email invitations to a web questionnaire and were offered an equivalent of $2 for completing the study. The questionnaire included the vignette experiment and items on frequency and types of smartphone use, privacy and security concerns, and trust in different organizations that collect personal data (Appendix, section A). The research design was reviewed by the Ethics Committee at the University of Mannheim. A total of 8,080 panel members were invited to participate in the study and 1,876 completed the survey, resulting in a survey completion rate of 23.2 percent (COMR; see AAPOR 2016) and a cumulative response rate of 3.3 percent (CUMRR, i.e., including recruitment into the panel and participation in this particular survey; see AAPOR 2016).[3] The median response time was 8 min.

Vignette studies allow us to simultaneously assess the effect of several study characteristics on willingness to participate in smartphone-based research and benefit from both the internal validity of experimental designs and the external validity of population-representative samples (Sniderman and Grob 1996; Atzmüller and Steiner 2010). In survey methodology, vignette studies have previously been employed to evaluate the effect of different study characteristics on hypothetical willingness to give consent to web survey paradata collection (Couper and Singer 2013), participate in surveys (Singer 2003; Couper et al. 2008; Couper et al. 2010), and engage in mobile

1. Additional information about the AmeriSpeak Panel recruitment and management can be found at https://amerispeak.norc.org/about-amerispeak/Pages/Panel-Design.aspx.

2. The research design of the vignette experiment and the hypotheses were preregistered in the study proposal, which is available at https://osf.io/b87sm/.

3. Probability-based online panels were shown to outperform nonprobability online panels in terms of data quality and representation of the general population, even if they have modest response rates (e.g., Yeager et al. 2011; MacInnis et al. 2018; Cornesse et al. 2020; Hargittai and Shaw 2020).

app and sensor data collection (Keusch et al. 2019; Gerdon et al. 2021). Our study expands upon the earlier vignette experiment by Keusch et al. (2019). Since the focus of vignette studies is to compare different study scenarios, they only allow measuring stated willingness to participate in research rather than actual participation. However, previous research on the external validity of vignette studies has shown that hypothetical survey-based measures of behavior can be highly correlated with actual behavior (Hainmueller, Hangartner, and Yamamoto 2015). With regard to participation in smartphone-based studies, Struminskaya et al. (2021), for example, used data from a general population survey in the Netherlands and found that 69 percent of respondents who stated that they were willing to share their GPS location actually shared their data. For other tasks, such as sharing videos or photos taken from the smartphone, the compliance rate was even 100 percent.

## Vignettes

The vignettes contained descriptions of hypothetical studies that would invite respondents to download a research app on their smartphone. Respondents who reported not using a smartphone were informed that they would be provided with a device for the purpose of the study. The research app would administer survey questions about individuals' time use and collect data about the technical characteristics of their phone, whether their phone is currently in motion, their current location, what apps are used, and what websites are visited, as well as the number of incoming and outgoing phone calls and text messages on their phone. Figure 2 shows a vignette example.

Five study characteristics were randomly varied in the vignettes (table 1): the readability of the data protection and privacy statement[4] (related to H1.1), whether technical support for app installation is provided (H2.1), the type of control that respondents have over the data collection process (H3.1), the type of monetary incentive[5] (H4.1 and H4.2), and whether personalized feedback is provided (H4.3).

4. The statements were designed such that they have the same text length (i.e., number of words), but differ in their readability, considering the number of sentences, the number of words per sentence, and the number of syllables per word. The readability of both versions was assessed with the Flesch Reading Ease Test (Flesch 1948) implemented in Microsoft Word, with lower scores indicating texts that are more difficult to understand. The simple version has a score of 51.3, while the difficult version has a score of 19.9. Converted to US grade reading level, the simple version would require 9.5 years of education to understand the text and the difficult version would require 15.7 years of education.

5. The data collection tasks presented in the vignettes are more complex compared to the studies that the AmeriSpeak panel members are usually invited to. The incentive amount was therefore designed to be equivalent to the AmeriSpeak incentive paid to panel members for completing their first survey.

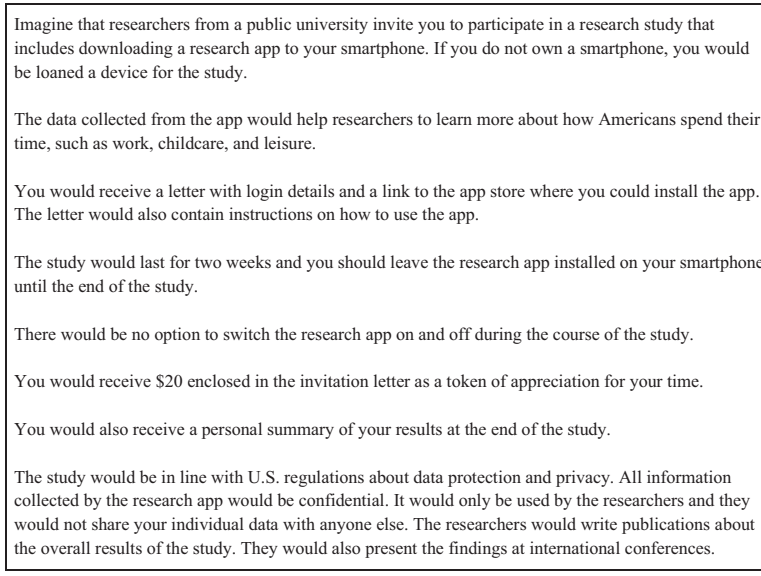


**Figure 2.** Vignette example.

The experimental design (2x2x3x3x2) results in a vignette universe of 72 unique descriptions, and respondents were randomly assigned to eight vignettes without replacement. After each vignette, they were asked to rate their willingness to participate in the described hypothetical study (Q3: "How likely is it that you would download the app to participate in this research study?") on a scale from 0 ("Definitely would not participate") to 10 ("Definitely would participate").

As a manipulation check, we included a question after the last vignette about whether respondents noticed any differences between the vignettes (Q4). We find that 83 percent of respondents reported that they noticed differences. To check for robustness, we ran our analysis by excluding respondents who reported that they did not notice any differences or took five seconds or less to read and respond to a vignette, in line with Keusch et al. (2019). In addition, we ran our analysis by excluding respondents who do not personally use a smartphone. In both cases, the results were highly comparable and we, thus, only present the results for the total sample.

## Willingness to Participate

The main outcome variable is stated willingness to download the research app on a smartphone. We dichotomized the 11-point scale into respondents who would not download (0 to 5) and those who would download the app (6

**Table 1.** Willingness to participate in mobile app and sensor data collection by vignette dimensions.

| Vignette text | % willing to participate (standard error) |
|---|---|
| Data protection and privacy statement | |
| Easy | |
| The study would be in line with U.S. regulations about data protection and privacy. All information collected by the research app would be confidential. It would only be used by the researchers and they would not share your individual data with anyone else. The researchers would write publications about the overall results of the study. They would also present the findings at international conferences. | 43.5 (0.008) |
| Difficult | |
| The study would be in compliance with prevailing U.S. data protection and privacy regulations and several procedures would be in place to preserve the confidentiality of all information collected by the research app. Any data collected would only be used by the principal investigators and would not be shared with any other parties. Aggregated study findings would be disseminated through publications and international conferences. | 44.9 (0.008) |
| Technical support for app installation | |
| Yes | |
| You would receive a letter and a phone call from an interviewer who would walk you through all steps to install the app. They would also show you how to use the app and answer any questions you may have. | 42.8 (0.008) |
| No | |
| You would receive a letter with login details and a link to the app store where you could install the app. The letter would also contain instructions on how to use the app. | 45.6 (0.008) |
| Control over data collection | |
| Turn off data collection | |
| The research app would allow you to switch it off at times when you do not want it to collect any data from your smartphone. However, it would be important for this study that you use this option only in rare cases and for short periods. | 45.1 (0.009) |
| Review data before submission | |
| The research app would allow you to review the data that have been collected and you would have the option to delete specific data points when you do not want them to be transmitted to the researcher. However, it would be important for this study that you use this option only in rare cases. | 47.7 (0.009) |

(continued)

**Table 1.** Continued.

| Vignette text | % willing to participate (standard error) |
|---|---|
| No | |
| There would be no option to switch the research app on and off during the course of the study. | 39.7 (0.009) |
| Monetary incentive | |
| Unconditional | |
| You would receive $20 enclosed in the invitation letter as a token of appreciation for your time. | 46.6 (0.009) |
| Conditional with incremental amount | |
| You would receive $6 for downloading the app and $1 for every day that you leave the app installed on your smartphone, resulting in a maximum amount of $20. | 42.8 (0.009) |
| Conditional with fixed amount | |
| You would receive $20 for downloading the app and leaving it installed on your smartphone until the end of the study. | 43.2 (0.009) |
| Feedback | |
| Yes | |
| You would also receive a personal summary of your results at the end of the study. | 44.6 (0.008) |
| No | |
| – | 43.9 (0.008) |

to 10), following prior research (Couper et al. 2008; Couper et al. 2010; Keusch et al. 2019). Dichotomizing the willingness variable reflects the binary nature of the decision to participate in a study and allows estimating participation rates for the different scenarios described in the vignettes. We also performed sensitivity analyses by using a different cutoff point for creating the dichotomized outcome measure (0–4 vs. 5–10), using the original 11-point scale as ordinal outcome measure, and restricting the analysis to respondents who selected the extreme points (0 vs. 10). The different operationalizations had only minor effects on the analyses and the conclusions.

## Measures

The experimental variation of the study characteristics in the vignettes results in five independent variables for our analysis. To examine the hypothesized

interactions between study and respondent characteristics (related to H1.2, H2.2, and H3.2), we include the following additional variables in the models: security concerns toward research apps (0–6), number of perceived privacy violations offline (0–4), number of perceived privacy violations online (0–3), trust in organizations involved with mobile data collection (0–9), use of a smartphone (yes, no), frequency of smartphone use (0–4), and number of smartphone activities (0–12).[6] To analyze whether the treatments are more effective in increasing WTP for certain subgroups, we also include age, gender, race/ethnicity,[7] and education in the models, which come from a profile survey that panel members were asked to complete upon registration. Table 2 shows the descriptive statistics of all measures used in the analysis.

## Analysis Strategy

The data preparation and analysis were conducted in R version 4.0.4 (R Core Team 2021). To test the hypotheses specified above, we first examine the main effects of the study characteristics that were experimentally varied in the vignettes, controlling for age, gender, race/ethnicity, and educational attainment. We estimate multilevel logistic regression models to account for the hierarchical structure of the data, with responses to the eight vignettes nested within respondents, using the R lme4 package version 1.1.26 (Bates et al. 2015). For easier interpretation of the regression coefficients, we calculate average marginal effects using the R margins package version 0.3.26 (Leeper 2021).

In additional regression models, we explore the hypothesized interaction effects of study and respondent characteristics, including privacy concerns, educational attainment, and smartphone proficiency, on willingness to download the research app. Finally, we estimate regression models to examine interaction effects of study characteristics and sociodemographics, with the aim of identifying any subgroup differences in treatment. We use the R sjPlot package version 2.8.10 (Lüdecke 2021) and the R ggplot2 package version 3.3.5 (Wickham 2016) to visualize the results.

In all regression models, we control for the order of vignettes shown to respondents (1 vs. 2–8) since willingness to participate in smartphone-based research is likely to be higher for the first task request than for any subsequent requests (Silber et al. 2018; Keusch et al. 2019; Struminskaya et al.

6. See Appendix, section B for more details about how these variables were operationalized.

7. Race/ethnicity was dichotomized into "White" vs. "Non-White" due to the skewness of the response distribution. We replicated the analysis by splitting "Non-White" into further categories, but the conclusions remain unchanged.

**Table 2.** Descriptive statistics of covariates (unweighted).

| Numeric variables | Mean | Standard deviation | Range | Missing values |
|---|---|---|---|---|
| *Sociodemographics* | | | | |
| Age | 49.2 | 16.9 | 18–94 | 0 |
| *Privacy and security concerns and trust* | | | | |
| Security concerns research apps | 3.2 | 1.8 | 0–6 | 16 |
| No. perceived privacy violations offline | 1.7 | 1.5 | 0–4 | 16 |
| No. perceived privacy violations online | 2.6 | 0.8 | 0–3 | 22 |
| Trust data not shared by organizations | 3.7 | 2.1 | 0–9 | 18 |
| *Smartphone proficiency* | | | | |
| Frequency of smartphone use | 3.3 | 1.2 | 0–4 | 9 |
| No. smartphone activities | 9.2 | 3.3 | 0–12 | 56 |

| Categorical variables | % | Missing values |
|---|---|---|
| *Sociodemographics* | | |
| Gender | | |
| Female | 52.5 | 0 |
| Male | 47.5 | |
| Race/ethnicity | | |
| White | 64.9 | 0 |
| Non-white | 35.1 | |
| Education | | |
| No high school degree | 4.1 | 0 |
| High school degree | 17.0 | |
| College degree | 78.9 | |
| *Smartphone proficiency* | | |
| Uses a smartphone | | |
| Yes | 96.0 | 7 |
| No | 4.0 | |

*Note:* A small proportion of missing values on these measures (<3 %) were imputed with a chained-equations algorithm by using the R mice package version 3.13.0 (van Buuren and Groothuis-Oudshoorn 2011).

2020b). We calculate weighted estimates with the R srvyr package version 1.1.0 (Freedman Ellis and Schneider 2021), applying the weights provided by NORC to correct for sampling and nonresponse biases. The weight consists of a base weight adjusting for the probability of selection, a panel raking weight based on demographic distributions from the Current Population Survey to adjust for panel nonresponse, and a study-specific poststratification weight to adjust for study-specific nonresponse.

# Results

## Willingness to Participate

Across all eight vignettes, an average of 44 percent of respondents reported that they would be willing to download the research app to participate in the described studies. Twenty-eight percent of respondents consistently indicated that they would be willing to participate in all eight of the presented studies, whereas 40 percent would not participate in any of the studies. Thirty-four percent of respondents used the same response option on the 11-point willingness scale for all eight vignettes. Table 1 shows the percentage of willingness to participate in the described studies by vignette dimensions.

## Main Effects of Study and Respondent Characteristics on Willingness to Participate

To examine the effect of study characteristics and respondent characteristics on willingness to participate in mobile app and sensor data collection, we estimate a series of multilevel logistic regression models with random intercepts. We first fit a base model without covariates (Model 0 in the footnote of Supplementary Material table S1) to partition the total variance of willingness ratings into within- and between-respondent components. The model shows that 82 percent of the variance originates from the respondents, suggesting that their willingness ratings are rather stable across the vignettes.[8]

We next fit a model of willingness to participate in smartphone-based data collection on the five study characteristics that were experimentally varied in the vignettes, controlling for vignette order and sociodemographics (Supplementary Material table S1). Providing simpler data protection and privacy statements in the study invitation has no significant influence on individuals' willingness to participate in smartphone-based data collection, showing no support for H1.1.

Contrary to our expectation, providing technical support during app installation significantly decreases individuals' willingness ($p < .001$), not supporting H2.1. The predicted probabilities of being willing to participate in smartphone-based data collection decrease by two percentage points if respondents receive an invitation letter and a phone call from an interviewer who would help them to install the app rather than just receiving a letter with log-in details and a link to the app store where they could install the app on their own.

8. To measure within-person variance on the original willingness measure, we also fit a baseline model with the 11-point scale as outcome variable. The results indicate an intraclass correlation of 0.85, which further shows that respondents provided similar answers across the eight different vignettes.

Supporting H3.1, giving respondents more control over their data during the data collection process significantly increases their willingness ($p < .001$). Respondents have six percentage points higher predicted probabilities of being willing to participate in smartphone-based data collection if they can temporarily switch off the research app when they do not want it to collect any data from their smartphone as opposed to not having this option. Furthermore, they have eight percentage points higher predicted probabilities of willingness if they are offered to review the data that have been collected and delete specific data points that they do not want to be transmitted to the researcher.

Supporting H4.1, we also find that offering unconditional monetary incentives significantly increases individuals' willingness to participate in smartphone-based research over conditional monetary incentives ($p = .010$ for conditional with fixed amount vs. unconditional; $p < .001$ for conditional with incremental amount vs. unconditional). The predicted probabilities of willingness decrease by two percentage points if respondents receive $20 conditional on downloading the app and leaving it installed on their smartphone until the end of the study (conditional with fixed amount) as opposed to receiving $20 enclosed in their invitation letter (unconditional). In addition, the predicted probabilities of willingness decrease by three percentage points if respondents receive $6 for downloading the app and $1 for every day that they leave the app installed on their smartphone (conditional with incremental amount) rather than receiving an unconditional monetary incentive. To compare the effects of the two conditional incentives, we estimate an additional model where we change the reference category of the "Monetary incentive" variable to "Conditional with fixed amount." Contrary to our expectation, paying out conditional incentives in incremental amounts significantly decreases individuals' willingness compared to paying them out in fixed amounts ($p = .008$), not supporting H4.2. Respondents have two percentage points lower predicted probabilities of being willing to participate in smartphone-based data collection if they receive $6 for downloading the app and $1 for every day that they leave the app installed on their smartphone rather than receiving a fixed amount of $20 for downloading the app and leaving it installed until the end of the study.

Finally, providing personalized feedback to respondents as a form of nonmonetary incentive has no significant influence on their willingness to participate in smartphone-based research, showing no support for H4.3. Among the additional variables included in the model, we find that individuals' willingness is significantly lower for the second to eighth vignette compared to the first vignette ($-3$ percentage points; $p < .001$) and willingness significantly decreases with age ($-0.6$ percentage points; $p < .001$). Furthermore, willingness to participate in smartphone-based data collection is significantly lower for white compared to non-white respondents

(−7 percentage points; $p = .003$) and significantly lower for respondents with a college degree compared to those with lower levels of education (−13 percentage points; $p = .012$). Finally, gender has no significant effect on willingness.

In Model 2, we additionally control for the main effects of privacy and security concerns, trust in organizations involved with mobile data collection, and smartphone proficiency (figure 3; Supplementary Material table S1). The effects of the five study characteristics and the other covariates remain unchanged, except for the effect of age, which becomes nonsignificant ($p = .065$). The results indicate that respondents with higher levels of security concerns toward research apps are significantly less willing to participate in mobile app and sensor data collection (−10 percentage points; $p < .001$). Similarly, those who perceived online privacy violations in a larger number of situations are significantly less willing to participate (−4 percentage points; $p < .001$), while the number of perceived offline privacy violations has no significant main effect on willingness. Respondents with higher levels of trust that different organizations will not share their personal data with other parties, in turn, are significantly more willing to participate in smartphone-based research (+4 percentage points; $p < .001$). Finally, smartphone proficiency also affects the level of willingness: respondents who personally use a smartphone and would, therefore, be asked to install the research app on their personal smartphone are significantly less willing to participate in mobile app and sensor data collection compared to those who indicated that they do not personally use a smartphone and would, therefore, be loaned a device for the study (−15 percentage points; $p = .006$). The type of smartphone use, however, also plays a role: respondents who use their smartphone for a larger variety of activities are significantly more willing to participate in smartphone-based data collection (+1 percentage points; $p = .004$), although the frequency of smartphone use has no significant effect on willingness.

## Interaction Effects of Study and Respondent Characteristics on Willingness to Participate

We next estimate a series of regression models to investigate the hypothesized interaction effects of study and respondent characteristics on willingness to participate in mobile app and sensor data collection. We do not find any significant interaction effects of the simplicity of the data protection and privacy statement and the level of privacy concerns or educational attainment (Supplementary Material table S2 and table S3), not supporting H1.2 and H1.3. Furthermore, the interaction effects of technical support provided during app installation and the level of smartphone proficiency are not significant (Supplementary Material table S4), not showing support

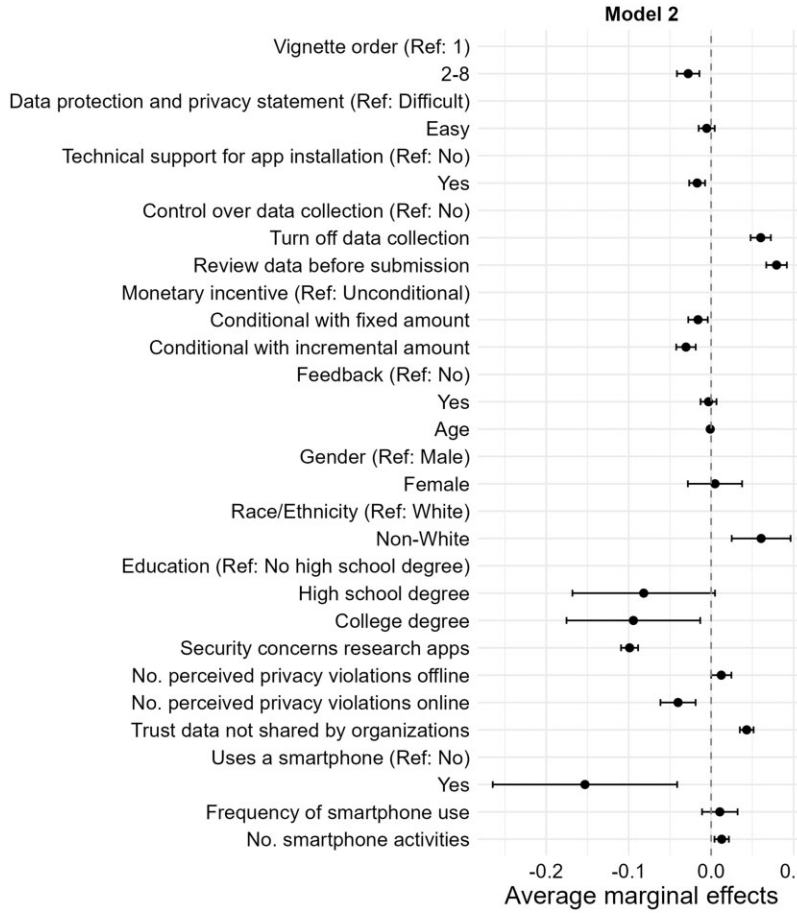


**Figure 3.** Average marginal effects (points) and 95 percent confidence intervals (lines) from multilevel logistic regression models of willingness to participate (WTP) in mobile app and sensor data collection.

for H2.2. For the interaction of control over data collection and privacy concerns, the results indicate a significant effect for one of the four indicators of privacy concerns ($p < .001$) but in a different direction than expected, not supporting H3.2 (figure 4, Model 12 in Supplementary Material table S5): offering the option to turn off the data collection or review the data before submission significantly increases the willingness to participate in smartphone-based data collection for individuals who perceived privacy violations offline across few situations. For individuals who perceived privacy violations offline in a larger number of scenarios,

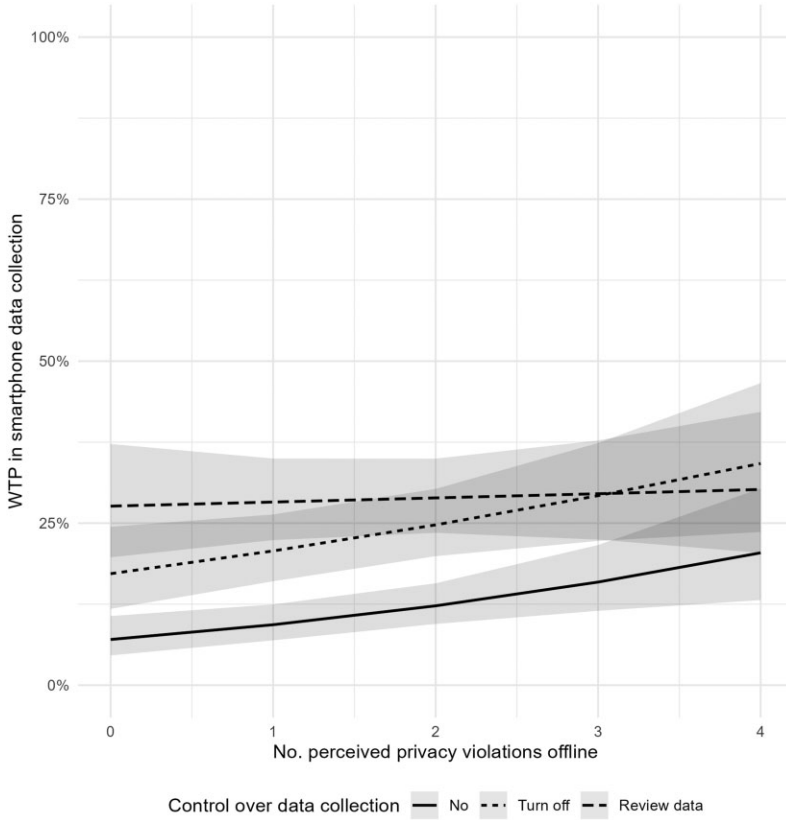


**Figure 4.** Predicted willingness to participate (WTP) in smartphone data collection (lines) with 95 percent confidence intervals (areas) by control over data collection and no. perceived privacy violations offline.

however, giving more control over data collection does not significantly affect willingness. For the three other indicators of privacy concerns, however, the interaction effects are not significant.

To identify potential subgroup differences in treatment, we fit a series of additional regression models that include interaction effects of the study characteristics and sociodemographic characteristics. The results show that giving participants control over data collection seems to be more effective in increasing participation rates for those with higher levels of educational attainment (figure 5, Model 15 in Supplementary Material table S6): individuals with a college degree are significantly more willing to participate in mobile app and sensor data collection if they can temporarily switch off the

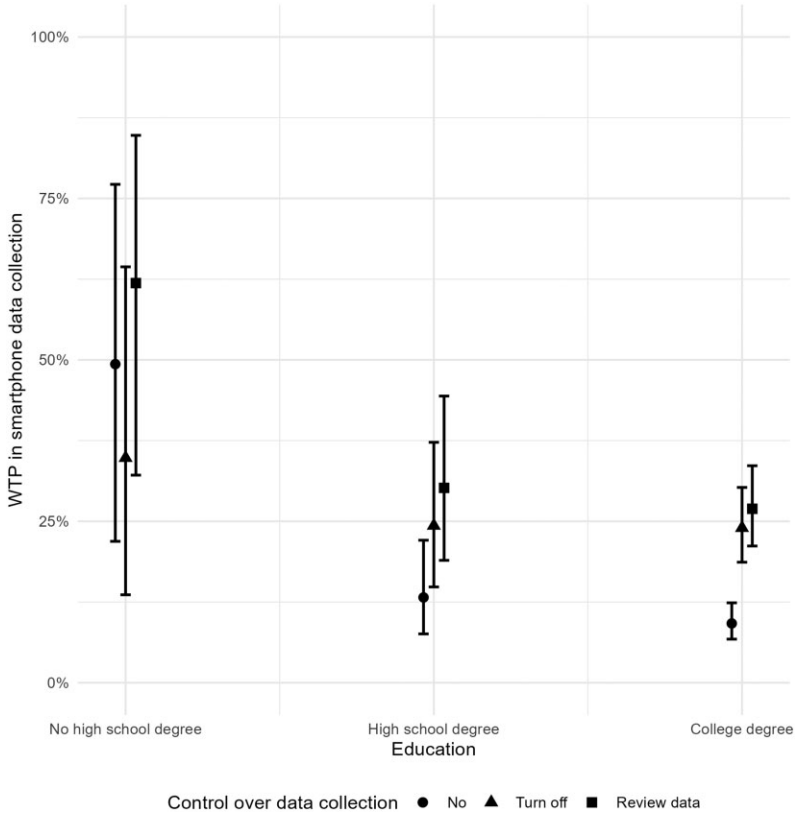


**Figure 5.** Predicted willingness to participate (WTP) in smartphone data collection (points) with 95 percent confidence intervals (lines) by control over data collection and educational attainment.

data collection or review the data prior to submission as opposed to not having this option[9] ($p < .001$). Giving these options to individuals with lower levels of educational attainment, however, does not lead to significant increases in their willingness to participate. For the other regression models, we do not find any significant interaction effects that are robust across the different operationalizations of the willingness measure.

9. The interaction effect remains significant when using a different cutoff point for the dichotomized measure (0–4 vs. 5–10) or using an ordinal measure. However, when restricting the analysis to respondents who selected the extreme points on the willingness scale (0 vs. 10), the interaction effect becomes insignificant, possibly due to the smaller sample size.

# Discussion

## Summary and Conclusions

Smartphone-based methods of data collection have recently been gaining popularity in the social sciences, allowing researchers to integrate survey data about people's attitudes and behavioral intentions and behavioral data that are passively collected from the smartphone's operating system and sensors. While an increasing number of research programs have trialed mobile app and sensor data collection in general population samples, the acceptance of these data collection methods in the society is typically low. We contribute to the literature by investigating features of the study design which are under the researcher's control and might be modified to increase people's willingness to participate in such studies.

Our results from a vignette experiment conducted in a probability-based panel of the general adult population in the United States show that giving study participants with higher levels of educational attainment more control over their data during the passive data collection process is a key strategy for increasing their willingness to participate in these studies. Offering these participants a chance to review the collected data and delete specific data points that they do not want to be transmitted to the researcher—increasing perceived trustworthiness as suggested by the Technology Acceptance Model (TAM)—seems to be slightly more effective than providing the option to temporarily switch off the data collection. While unit-level nonresponse can be reduced, there are additional errors that might be introduced through these methods, such as an increasing amount of missing data, arising from switching off the data collection, and measurement error, arising from selective data deletion. When choosing to implement this method, researchers need to be mindful of this potential error trade-off.

A second effective strategy to increase individuals' willingness to participate in mobile app and sensor data collection that we identified in the vignette experiment is the provision of unconditional rather than conditional incentives, which will increase the perceived use of the technology. This is also consistent with previous research in the survey context (Church 1993; Singer and Ye 2013). When researchers opt for conditional incentives, paying a fixed amount for downloading the app and leaving it installed at the end of the study period might be slightly more effective than paying incremental amounts for app download and for every day that participants leave the app installed on their smartphone.

Finally, the format of the study invitation was shown to play a role: individuals are more willing to participate in smartphone-based studies if they simply receive an invitation letter with a link to an app store rather than receiving an invitation letter and a phone call from an interviewer who

accompanies them in the app installation process, even among people with limited smartphone proficiency. This finding is contrary to our expectation that the technical support provided by the interviewer might enhance individuals' willingness to engage with mobile app and sensor data collection. The results are also in contrast with earlier research showing that individuals are more likely to install a research app on their smartphone if they are invited within a face-to-face interview rather than via postal letter (Jäckle et al. 2022). A potential explanation for the lower willingness is that respondents might have been deterred by the additional time that would be needed to take the phone call and might have preferred to install the app on their own. The information that an interviewer would talk them through installing the app might have also conveyed to respondents that the app installation might be a difficult task—the opposite of what would convey the perceived ease of use of the technology in the sense of the TAM. Future research could test the effectiveness of other forms of technical support that is, for example, just offered upon individual request on people's willingness to participate in smartphone-based studies.

Two of the examined strategies did not influence individuals' willingness to participate, including the provision of personalized feedback as a form of nonmonetary incentive, confirming earlier research (Wenz et al. 2020), and providing simpler data protection and privacy statements in the study invitation. In our study, we do not have any indication to what extent the respondents read and actually understood the respective data protection and privacy statements but would welcome future research that more closely examines how individuals process these statements.

In line with previous research, we find that individuals' willingness to participate in smartphone-based studies is highest for the vignette presented first compared to those presented later. For studies that intend to present multiple participation requests, we would recommend to first present the most important request to respondents.

The study also adds to the growing body of research on respondent-level determinants of willingness to participate in smartphone-based data collection. Our findings replicate previous research, showing that security concerns toward research apps as well as smartphone proficiency, measured as the number of activities carried out on the smartphone, are key predictors of stated willingness (Pinter 2015; Keusch et al. 2019; Revilla et al. 2019; Wenz et al. 2019; Struminskaya et al. 2020b). We also find that willingness is significantly related to race/ethnicity and education but not significantly related to gender and age (when controlling for other respondent characteristics), which is consistent with the mostly nonsignificant or mixed findings in existing research (Keusch et al. 2019; Revilla et al. 2019; Wenz et al. 2019; Struminskaya et al. 2020b; Struminskaya et al. 2021).

## Limitations

Our study is not free from limitations. People's acceptance of smartphone-based methods of data collection is likely to be overestimated in our study since we asked respondents through vignettes to self-report their willingness to participate in hypothetical research rather than observing their participation behavior in actual smartphone-based studies. Although previous research has provided evidence that stated willingness measured in vignette studies and actual participation can be highly correlated, we should still be careful with interpreting the willingness rates measured in our study and rather consider them as upper-bound estimates of actual participation. In addition, we assess the willingness to engage with smartphone data collection among panel members who regularly participate in surveys and are, thus, likely to be more cooperative and have more positive attitudes toward research than the general population. We also cannot rule out that the panel members' likelihood to complete the vignette study is potentially correlated with their willingness to participate in smartphone-based research, which, again, might have led to an overestimation of willingness in our study. Finally, our study has been conducted in the United States and might not generalize to other cultural settings. As smartphones become an increasingly popular method of data collection in the social sciences, more research is needed about the acceptance of such methods in the general population across different countries.

# Appendix

## A. Questionnaire

Q1.

Do you personally use a smartphone (with touchscreen, Internet access, and apps)?

Yes
No

Q2.
On the following pages, you will see 8 different scenarios which vary in a number of features. All scenarios will contain study invitations that ask participants to download a research app to a smartphone. [SHOW IF Q1. = No: Participants without a smartphone would be loaned a device for the study.]

The research app, when downloaded to a smartphone, would send short surveys about how people spend their time and collect the following data:

- Technical characteristics of the phone (for example, brand, screen size)
- Whether the phone is currently in motion

- The current location (every 5 minutes)
- What apps are used and what websites are visited on the phone
- The number of incoming and outgoing phone calls and text messages on the phone

Please note that the research app would only collect information on when other apps are opened or when a call is made. The research app could not see what happens inside other apps or what is said in a phone call or a text message.

Q3. [SHOW EIGHT VIGNETTES]

Please read Scenario #N carefully.

Imagine that researchers from a public university invite you to participate in a research study that includes downloading a research app to your smartphone. [SHOW IF Q2. = No: If you do not own a smartphone, you would be loaned a device for the study.]

The data collected from the app would help researchers to learn more about how Americans spend their time, such as work, childcare, and leisure.

#Technical support#

The study would last for two weeks and you should leave the research app installed on your smartphone until the end of the study.

#Control over data collection#
#Monetary incentive#
#Feedback#
#Data protection and privacy statement#

How likely is it that you would download the app to participate in this research study?

0 Definitely would not participate
1
2
3
4
5
6
7
8
9
10 Definitely would participate

Q4.

Did you notice any differences among the 8 different research study descriptions?

Yes
No

Q5. [SHOW IF Q1. = Yes]

How often do you use a smartphone for activities other than phone calls or text messaging?

Several times a day
Every day
Several times a week
Several times a month
Once a month or less

Q6. [SHOW IF Q1. = Yes; RANDOMIZE ORDER OF RESPONSE OPTIONS]

Do you use your smartphone for the following activities?

a. Browsing websites
b. Reading and/or writing email
c. Taking photos
d. Looking at content on social media websites/apps (for example looking at text, images, videos on Facebook, Twitter, Instagram)
e. Posting content to social media websites/apps (for example posting text, images, videos on Facebook, Twitter, Instagram)
f. Making purchases (for example buying books or clothes, booking train tickets, ordering food)
g. Online banking (for example checking account balance, transferring money)
h. Installing new apps (for example from iTunes, Google Play Store)
i. Using GPS/location-aware apps (for example Google Maps, Foursquare, Yelp)
j. Connecting to other electronic devices via Bluetooth (for example smartwatches, fitness bracelets, step counter)
k. Playing games
l. Streaming videos or music

Yes
No

Q7. [RANDOMIZE ORDER OF GRID ITEMS]

How concerned would you be about the security of providing information in the following ways for research?

a. Download an app to answer survey questions
b. Download an app which collects data about how the smartphone is being used

Not at all concerned
A little concerned
Somewhat concerned
Very concerned

Q8. [RANDOMIZE ORDER OF GRID ITEMS]

Please indicate whether or not you ever feel your privacy is violated by the following.

a. Banks and credit card companies when they ask about finances
b. The government when it collects tax returns
c. The federal government when it conducts surveys
d. People who ask questions on public opinion surveys
e. Social media platforms that store a lot of information about you
f. Apps collecting information about location when they are not used
g. Web browsers tracking websites you visit

Yes
No

Q9. [RANDOMIZE ORDER OF GRID ITEMS]

How much do you trust each of the following to not share your personal data with other parties?

a. University researchers
b. Your mobile phone network provider
c. Companies that make apps for smartphones

Do not trust at all
Trust a little
Trust somewhat
Trust a lot

### B. Operationalization of Privacy and Security Concerns, Trust in Organizations Involved with Mobile Data Collection, and Smartphone Proficiency

**Privacy and security concerns** were operationalized with several indicators. *Security concerns toward research apps* were measured based on a summed score (0–6) of two items about the level of security concerns when providing information through different types of research apps (Q7). Higher values indicate higher levels of security concerns. Based on a factor analysis on a seven-item grid question about perceived privacy violations across different domains (Q8), two index measures on the *number of perceived privacy violations offline* (0–4) and the *number of perceived privacy violations online* (0–3) were built. For both indices, higher values indicate that respondents felt that their privacy was violated in a larger number of situations.

**Trust in organizations involved with mobile data collection** was measured based on a three-item grid question about the level of trust in different organizations (Q9). The responses were summed up into an index ranging from 0 to 9, with higher values indicating higher levels of trust in the organizations.

**Smartphone proficiency** was operationalized with three indicators: *use of a smartphone* (Q1, yes vs. no), *frequency of smartphone use* (Q5, 0–4), and the *number of smartphone activities* (Q6, 0–12).

## Supplementary Material

Supplementary Material may be found in the online version of this article: https://doi.org/10.1093/poq/nfad019.

## Funding

Data collection for this study was supported by a grant to A.W. through the TESS (Time-sharing Experiments for the Social Sciences) Special Competition for Young Investigators. TESS is funded by the National Science Foundation (SES-2017581, Principal Investigators: Maureen Craig, James Druckman, and Jeremy Freese).

## Data Availability

Replication data, documentation, and analysis code are available at https://doi.org/10.17605/OSF.IO/PHFW2.

# References

AAPOR. 2016. *Standard Definitions. Final Dispositions of Case Codes and Outcome Rates for Surveys*. American Association for Public Opinion Research.

Antoun, Christopher, Frederick G. Conrad, Mick P. Couper, and Brady T. West. 2019. "Simultaneous Estimation of Multiple Sources of Error in a Smartphone-Based Survey." *Journal of Survey Statistics and Methodology* 7:93–117.

Atzmüller, Christiane, and Peter M. Steiner. 2010. "Experimental Vignette Studies in Survey Research." *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences* 6:128–38.

Bates, Douglas, Martin Mächler, Benjamin M. Bolker, and Steven C. Walker. 2015. "Fitting Linear Mixed-Effects Models Using lme4." *Journal of Statistical Software* 67:1–48.

Church, Allan H. 1993. "Estimating the Effect of Incentives on Mail Survey Response Rates: A Meta-Analysis." *Public Opinion Quarterly* 57:62–79.

Cornesse, Carina, Annelies G. Blom, David Dutwin, Jon A. Krosnick, Edith D. de Leeuw, Stéphane Legleye, Josh Pasek, Darren Pennay, Benjamin Phillips, Joseph W. Sakshaug, Bella Struminskaya, and Alexander Wenz. 2020. "A Review of Conceptual Approaches and Empirical Evidence on Probability and Nonprobability Sample Survey Research." *Journal of Survey Statistics and Methodology* 8:4–36.

Couper, Mick P., Garret Gremel, William Axinn, Heidi Guyer, James Wagner, and Brady T. West. 2018. "New Options for National Population Surveys: The Implications of Internet and Smartphone Coverage." *Social Science Research* 73:221–35.

Couper, Mick P., and Eleanor Singer. 2013. "Informed Consent for Web Paradata Use." *Survey Research Methods* 7:57–67.

Couper, Mick P., Eleanor Singer, Frederick G. Conrad, and Robert M. Groves. 2008. "Risk of Disclosure, Perceptions of Risk, and Concerns about Privacy and Confidentiality as Factors in Survey Participation." *Journal of Official Statistics* 24:255–75.

———. 2010. "Experimental Studies of Disclosure Risk, Disclosure Harm, Topic Sensitivity, and Survey Participation." *Journal of Official Statistics* 26:287–300.

Davis, Fred D. 1986. "A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results." Doctoral dissertation, MIT Sloan School of Management.

———. 1989. "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology." *MIS Quarterly* 13:319–40.

Edwards, Ben, and Nicholas Biddle. 2021. "Consent to Data Linkage: Experimental Evidence from an Online Panel." In *Advances in Longitudinal Survey Methodology*, edited by Peter Lynn, 181–203. Hoboken, NJ: Wiley.

Elevelt, Anne, Peter Lugtig, and Vera Toepoel. 2019. "Doing a Time Use Survey on Smartphones Only: What Factors Predict Nonresponse at Different Stages of the Survey Process?" *Survey Research Methods* 13:195–213.

Flesch, Rudolf. 1948. "A New Readability Yardstick." *Journal of Applied Psychology* 32: 221–33.

Freedman Ellis, Greg, and Ben Schneider. 2021. "srvyr: 'dplyr'-Like Syntax for Summary Statistics of Survey Data. R package version 1.1.0." https://cran.r-project.org/package=srvyr. Date accessed 22 February 2022.

Gefen, David, Elena Karahanna, and Detmar W. Straub. 2003. "Trust and TAM in Online Shopping: An Integrated Model." *MIS Quarterly* 27:51–90.

Gerdon, Frederic, Helen Nissenbaum, Ruben L. Bach, Frauke Kreuter, and Stefan Zins. 2021. "Individual Acceptance of Using Health Data for Private and Public Benefit: Changes during the COVID-19 Pandemic." *Harvard Data Science Review* 1–28.

Haas, Georg-Christoph, Frauke Kreuter, Florian Keusch, Mark Trappmann, and Sebastian Bähr. 2021. "Effects of Incentives in Smartphone Data Collection." In *Big Data Meets Survey Science: A Collection of Innovative Methods*, edited by Craig A. Hill, Paul P. Biemer, Trent D. Buskirk, Lilli Japec, Antje Kirchner, Stas Kolenikov, and Lars E. Lyberg, 389–414. Hoboken, NJ: Wiley.

Hainmueller, Jens, Dominik Hangartner, and Teppei Yamamoto. 2015. "Validating Vignette and Conjoint Survey Experiments against Real-World Behavior." *Proceedings of the National Academy of Sciences of the United States of America* 112:2395–400.

Harari, Gabriella M., Nicholas D. Lane, Rui Wang, Benjamin S. Crosier, Andrew T. Campbell, and Samuel D. Gosling. 2016. "Using Smartphones to Collect Behavioral Data in Psychological Science: Opportunities, Practical Considerations, and Challenges." *Perspectives on Psychological Science* 11:838–54.

Hargittai, Eszter, and Aaron Shaw. 2020. "Comparing Internet Experiences and Prosociality in Amazon Mechanical Turk and Population-Based Survey Samples." *Socius* 6:1–11.

Jäckle, Annette, Jonathan Burton, Mick P. Couper, Thomas F. Crossley, and Sandra Walzenbach. 2021. "Understanding and Improving Data Linkage Consent in Surveys." Understanding Society Working Paper 2021-01. Colchester: University of Essex. https://www.understandingsociety.ac.uk/sites/default/files/downloads/working-papers/2021-01.pdf. Date accessed 15 June 2022.

Jäckle, Annette, Jonathan Burton, Mick P. Couper, and Carli Lessof. 2019. "Participation in a Mobile App Survey to Collect Expenditure Data as Part of a Large-Scale Probability Household Panel: Coverage and Participation Rates and Biases." *Survey Research Methods* 13:23–44.

Jäckle, Annette, Alexander Wenz, Jonathan Burton, and Mick P. Couper. 2022. "Increasing Participation in a Mobile App Study: The Effects of a Sequential Mixed-Mode Design and In-Interview Invitation." *Journal of Survey Statistics and Methodology* 10:898–922.

Keusch, Florian, Sebastian Bähr, Georg-Christoph Haas, Frauke Kreuter, Mark Trappmann, and Stephanie Eckman. 2022. "Non-Participation in Smartphone Data Collection Using Research Apps." *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 185: S225–S245.

Keusch, Florian, Sebastian Bähr, Georg-Christoph Haas, Frauke Kreuter, and Mark Trappmann. 2023. "Coverage Error in Data Collection Combining Mobile Surveys with Passive Measurement Using Apps: Data from a German National Survey." *Sociological Methods & Research* 52:841–78.

Keusch, Florian, and Frederick G. Conrad. 2022. "Using Smartphones to Capture and Combine Self-Reports and Passively Measured Behavior in Social Research." *Journal of Survey Statistics and Methodology* 10:863–885.

Keusch, Florian, and Frauke Kreuter. 2022. "Digital Trace Data: Modes of Data Collection, Applications, and Errors at a Glance." In *Handbook of Computational Social Science, Volume 1: Theory, Case Studies and Ethics*, edited by Uwe Engel, Anabel Quan-Haase, Sunny Xun Liu, and Lars Lyberg, 100–18. London: Routledge.

Keusch, Florian, Bella Struminskaya, Christopher Antoun, Mick P. Couper, and Frauke Kreuter. 2019. "Willingness to Participate in Passive Mobile Data Collection." *Public Opinion Quarterly* 83:210–35.

Kreuter, Frauke, Georg-Christoph Haas, Florian Keusch, Sebastian Bähr, and Mark Trappmann. 2020. "Collecting Survey and Smartphone Sensor Data with an App: Opportunities and Challenges around Privacy and Informed Consent." *Social Science Computer Review* 38: 533–49.

Lawes, Mario, Clemens Hetschko, Joseph W. Sakshaug, and Stephan Grießemer. 2022. "Contact Modes and Participation in App-Based Smartphone Surveys: Evidence from a Large-Scale Experiment." *Social Science Computer Review* 40:1076–1092.

Leeper, Thomas J. 2021. "margins: Marginal Effects for Model Objects. R package version 0.3.26." https://cran.r-project.org/package=margins. Date accessed 22 February 2022.

Link, Michael W., Joe Murphy, Michael F. Schober, Trent D. Buskirk, Jennifer Hunter Childs, and Casey Langer Tesfaye. 2014. "Mobile Technologies for Conducting, Augmenting and Potentially Replacing Surveys: Executive Summary of the AAPOR Task Force on Emerging Technologies in Public Opinion Research." *Public Opinion Quarterly* 78:779–87.

Lüdecke, Daniel. 2021. "sjPlot: Data Visualization for Statistics in Social Science. R package version 2.8.10." https://cran.r-project.org/package=sjPlot. Date accessed 22 February 2022.

MacInnis, Bo, Jon A. Krosnick, Annabell S. Ho, and Mu-Jung Cho. 2018. "The Accuracy of Measurements with Probability and Nonprobability Survey Samples: Replication and Extension." *Public Opinion Quarterly* 82:707–44.

McCool, Danielle, Peter Lugtig, Ole Mussmann, and Barry Schouten. 2021. "An App-Assisted Travel Survey in Official Statistics: Possibilities and Challenges." *Journal of Official Statistics* 37:149–70.

Pew Research Center. 2019. "Americans and Privacy: Concerned, Confused and Feeling Lack of Control over Their Personal Information." https://www.pewresearch.org/internet/2019/11/15/americans-and-privacy-concerned-confused-and-feeling-lack-of-control-over-their-personal-information/. Date accessed 22 February 2022.

Pinter, Robert. 2015. "Willingness of Online Access Panel Members to Participate in Smartphone Application-Based Research." In *Mobile Research Methods: Opportunities and Challenges of Mobile Research Methodologies*, edited by Daniele Toninelli, Robert Pinter, and Pablo de Pedraza, 141–56. London: Ubiquity Press.

R Core Team. 2021. "R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing." https://www.r-project.org/. Date accessed 22 February 2022.

Revilla, Melanie, Mick P. Couper, and Carlos Ochoa. 2019. "Willingness of Online Panelists to Perform Additional Tasks." *Methods, Data, Analyses* 13:223–51.

Revilla, Melanie, Daniele Toninelli, Carlos Ochoa, and Germán Loewe. 2016. "Do Online Access Panels Need to Allow and Adapt Surveys to Mobile Devices?" *Internet Research* 26: 1209–27.

Roque, Nelson A., and Walter R. Boot. 2018. "A New Tool for Assessing Mobile Device Proficiency in Older Adults: The Mobile Device Proficiency Questionnaire." *Journal of Applied Gerontology* 37:131–56.

Sakshaug, Joseph W., Alexandra Schmucker, Frauke Kreuter, Mick. P. Couper, and Leonie Holtmann. 2021. "Respondent Understanding of Data Linkage Consent." *Survey Methods: Insights from the Field*.

Scherpenzeel, Annette. 2017. "Mixing Online Panel Data Collection with Innovative Methods." In *Methodische Probleme von Mixed-Mode-Ansätzen in der Umfrageforschung*, edited by Stefanie Eifler and Frank Faulbaum, 27–49. Wiesbaden: Springer.

Silber, Henning, Bernd Weiss, Florian Keusch, Christoph Beuthner, and Jette Schröder. 2018. "Framing Consent Questions in Mobile Surveys: Experiments on Question Wording." Paper presented at the BigSurv18 Conference, Barcelona, Spain, October 27.

Singer, Eleanor. 2003. "Exploring the Meaning of Consent: Participation in Research and Beliefs about Risks and Benefits." *Journal of Official Statistics* 19:273–85.

Singer, Eleanor, and Cong Ye. 2013. "The Use and Effects of Incentives in Surveys." *Annals of the American Academy of Political and Social Science* 645:112–41.

Sniderman, Paul M., and Douglas B. Grob. 1996. "Innovations in Experimental Design in Attitude Surveys." *Annual Review of Sociology* 22:377–99.

Struminskaya, Bella, Peter Lugtig, Florian Keusch, and Jan Karem Höhne. 2020a. "Augmenting Surveys with Data from Sensors and Apps: Opportunities and Challenges." *Social Science Computer Review* 1–13.

Struminskaya, Bella, Peter Lugtig, Vera Toepoel, Barry Schouten, Deirdre Giesen, and Ralph Dolmans. 2021. "Sharing Data Collected with Smartphone Sensors." *Public Opinion Quarterly* 85:423–62.

Struminskaya, Bella, Vera Toepoel, Peter Lugtig, Marieke Haan, Annemieke Luiten, and Barry Schouten. 2020b. "Understanding Willingness to Share Smartphone-Sensor Data." *Public Opinion Quarterly* 84:725–59.

Sugie, Naomi F. 2018. "Utilizing Smartphones to Study Disadvantaged and Hard-to-Reach Groups." *Sociological Methods & Research* 47:458–91.

van Buuren, Stef, and Karin Groothuis-Oudshoorn. 2011. "mice: Multivariate Imputation by Chained Equations in R." *Journal of Statistical Software* 45:1–67.

Wenz, Alexander, Annette Jäckle, Jonathan Burton, and Mick P. Couper. 2020. "The Effects of Personalized Feedback on Participation and Reporting in Mobile App Data Collection." *Social Science Computer Review* 40:165–78.

Wenz, Alexander, Annette Jäckle, and Mick P. Couper. 2019. "Willingness to Use Mobile Technologies for Data Collection in a Probability Household Panel." *Survey Research Methods* 13:1–22.

Wickham, Hadley. 2016. *ggplot2: Elegant Graphics for Data Analysis*. New York: Springer.

Yeager, David S., Jon A. Krosnick, Linchiat Chang, Harold S. Javitz, Matthew S. Levendusky, Alberto Simpser, and Rui Wang. 2011. "Comparing the Accuracy of RDD Telephone Surveys and Internet Surveys Conducted with Probability and Non-Probability Samples." *Public Opinion Quarterly* 75:709–47.

York Cornwell, Erin, and Kathleen A. Cagney. 2017. "Aging in Activity Space: Results from Smartphone-Based GPS-Tracking of Urban Seniors." *Journals of Gerontology: Series B Psychological Sciences and Social Sciences* 72:864–75.